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The deviation analysis-comparison between two non contact 3D scanners

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ABSTRACT

The objective of the project is to be able to generate part-to-CAD and CAD-to-part reconstruction of the original for future usage. There are several types of 3D scanners used for recording the point cloud data. Two types of non-contact scanners are used in this

project to record data points of the component, they are **3D SYSTEMS CAPTURE SCANNER** (photo phenomenon), **EIN SCANNER** (white light phenomenon), Using a free form surface which is modelled in CAD and manufactured under CNC. Using both scanners individually we scan the component by multiple operations. The data obtained by the scanners is converted into ASCII (.ASC) file format type which is further developed by SCAN 3D in CREO REX3.0. In the study of these scanners the standard and tolerance distributed are investigated and analogize the Reverse engineering based model with the original CAD model.

Keywords: Non contact scanners, free form surface, point cloud data, creorex3.0.

1. INTRODUCTION

Reverse engineering is the opposite of forward engineering which is opposite to conventional engineering manufacturing process. The principle behind reverse engineering is to be able to generate part –to-CAD and CAD- to-part reconstruction of the original for further usage. In the process of reverse engineering, It takes an existing product, digitize the product and creates a CAD model. Digitized points which are obtained in the CAD package are called point cloud data. Using this point cloud data surface can be generated or modified.**[1]** This generated surface using point cloud data is known as reverse engineered surface and later acquired regenerated surface is allowed for manufacturing.

In the process of reverse engineering part model digitization plays a major role for data acquisition of a free form surface, in this article author had used 3D scanner which is a device that scans real world objects to collect data on their shape and their appearance with dimensions up to most accurate level. They can only collect information about surfaces that are not obscured. In some cases Multiple scans from many different directions are requires to obtain information about all sides of the component**,** The purpose of a 3d scanner is usually to create a point cloud of geometric samples on the surface of the component .These scanning data are meshed to create a complete model. Each technology comes with its own advantages and limitations; collected 3d data is useful for a wide variety of applications. For example: It is used to construct digital three dimensional models, to identify curvature of the product.

1.1. 3D scanners are classified mainly two types

1. Contact type scanner: These scanners collect measurement data by physically scanning the component with a device that comes into contact with every point on the surface.
2. Non-contact type scanner: These collect immense amount of data quickly without altering the geometry of the component. This is also an advantage for collecting measurements on the nano-scale.**[2]**
3. Hybrid technique scanner: in this both contact and non-contact scanner techniques are used in data acquisition.

1.2. Surface reconstruction

An iterative process for 3D construction of the surfaces in static environment is defined by the following steps

- Acquiring image range of the freeform surface
- Pre-processing obtained data it is even called as data segmentation
- Data integration or data post-processing
- Reconstructing 3D CAD model

2. SCANNERS

There are many types of scanners and scanning methods but we deal with the following 2 types of noncontact scanners they are:

2.1. EINSCAN scanner

Einscan 3Dscanner works on white light phenomenon. In this white beam of light is projected over a freeform surface of the physical part model. It works in a combination of structured light 3D scanner. The Einscan3d scanner can be used by anyone to quickly and easily scan 3d models, this scanner can be carried away easily and it is portable **[3]**. All we have to perform is “point and click” and this process turns real world objects into 3d digital models.

Table 1
Specifications of Einscan

Scan volume	200*200*200 mm (automatic scan) and 700*700*700mm (free scan)
Resolution	1.3 Mega pixel
Point to point distance	0.17-0.02mm
Accuracy	<0.1mm
Scan speed	< 3 mins (automatic scan)and <10sec (free scan)

In this EINSCAN Scanner is placed on a tripod which ejects a white light form it this falls on the freeform surface of the physical part model which is placed on a turning table. This digitalised data can be obtained in the form of .asc file, IGES file, and STL file.

Figure 1
Ein scanner with structured light phenomenon.

Figure 2
EIN scanner scanning the component.

2.2. 3D systems capture scanner

The 3Dsystem capture scanners works on the principle of fast blue light 3D scanning technique. This scanner is comparatively expensive provide accurate point cloud data. It is very much portable and easily transported. The main advantage of this scanner is it is easy to access multiple scanner configuration, lost data of 3D cad model for highly complex and broken parts of the model can be easily created.

Table 2

Specifications of capture scanner

Properties	Specification
Weight	1.35kg
Data capture rate	985,000 points/scan(0.3 sec per scan)
Accuracy	0.060mm
Stand off distance	300mm
Depth of field	180mm
Resolution	0.110mm at 300mm 0.130mm at 480mm

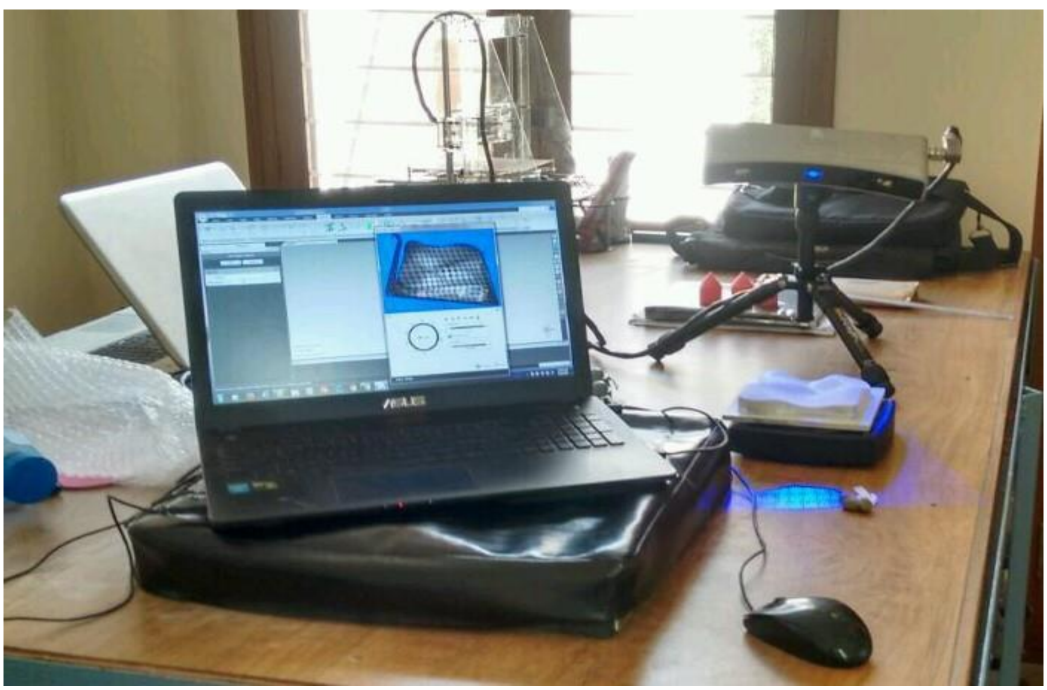


Figure 3

Capture scanner with fast blue light phenomenon

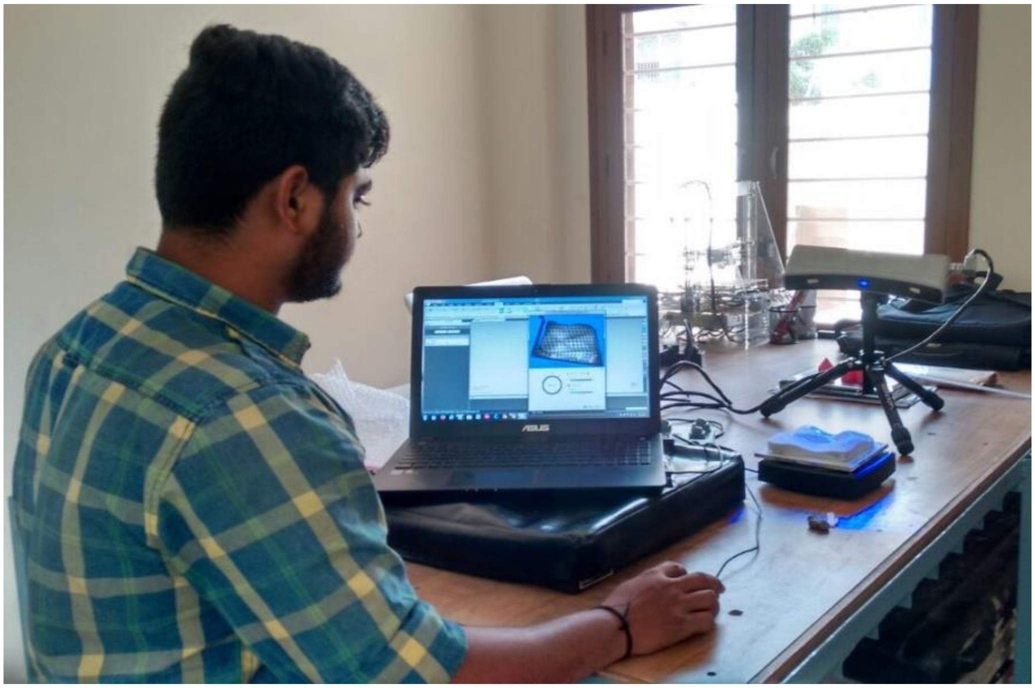


Figure 4

Performing scanning operation on freeform surface using capture scanner

3. METHODOLOGY

In this comparative study between the scanners having white light phenomenon and fast blue light phenomenon is made by using reverse engineering technique. The step by step procedure followed in this process is listed below.

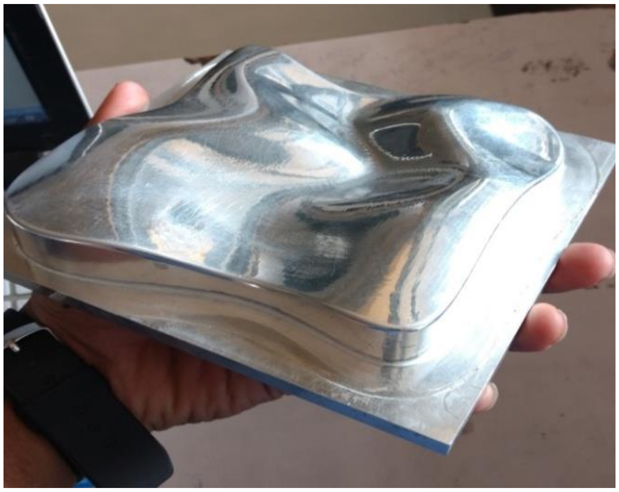
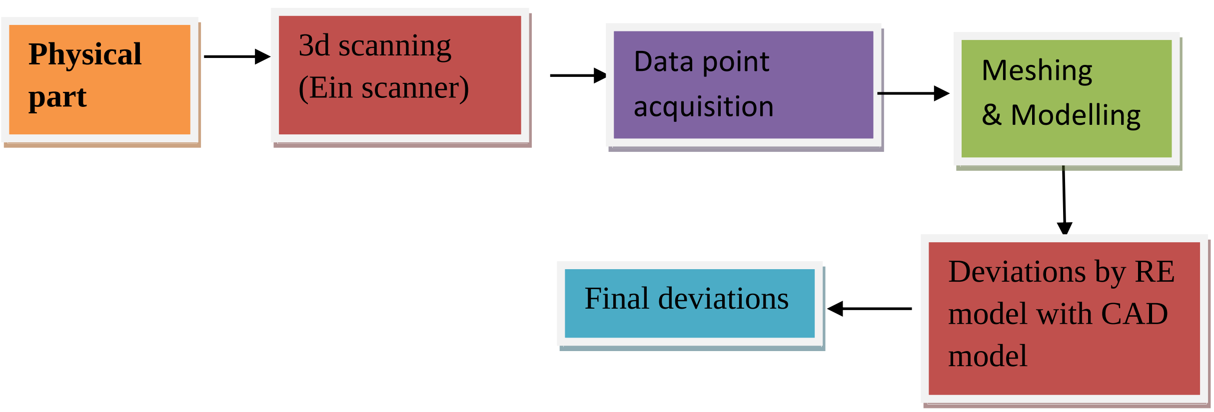


Figure 5

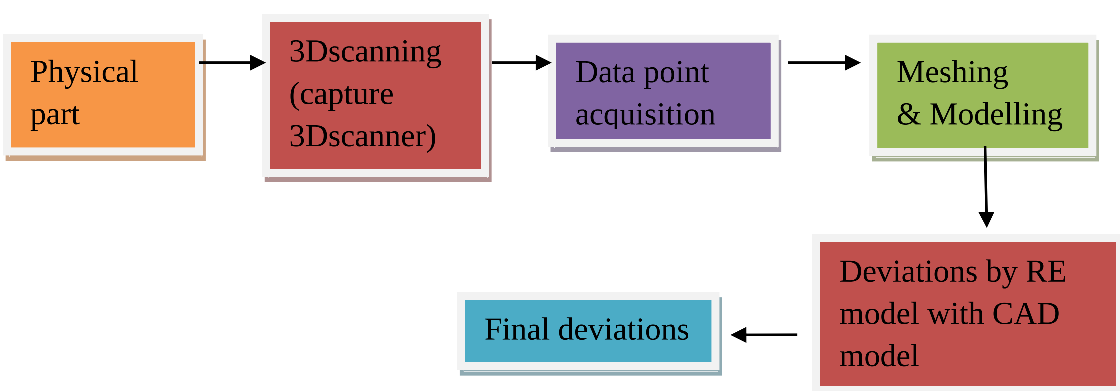
Physical part consisting of complex free form surface

3.1. Surface reconstruction using Einscan



Here a required physical part is placed scanned by using Ein scanner which uses white light phenomenon then processed to data acquisition where the measurements data of the physical part are recorded and saved. This data is imported into CreoRex software then meshing and modelling is done in order to obtain reconstructed surface, before the surface is obtained a several aspects should be performed in the software such as mesh sketching, smoothing, reduction of noise is smoothen over the freeform surface.**[5]** This finally gives us the reverse engineering model and it is further compared with the original CAD model in order to get deviations of the individual points of the freeform surface.

3.2. Surface reconstruction using 3D systems capture 3D scanner



The process involved for finding deviations is same as the above mentioned Ein scan followed modelling process but here we use the 3Dsystem Capture scanner where fast blue light phenomenon is involved.

4. EXPERIMENTAL WORK

In this paper of reverse engineering the point data of physical part (i.e, freeform surface) is obtained by using two non contact type scanners which are EIN SCAN & 3D SYSTEM CAPTURE SCANNER, which consists of white light phenomenon and fast blue light phenomenon respectively. The component is selected in such a way that it satisfies the scanning criteria and it should be a complex freeform shape for scanning so that the accuracy is determined precisely.**[6]**

- The number of data points obtained by EinScan are **661922.**

- Whereas the number of data points obtained by 3D systems capture scanner has **199840** data points for the same free form surface of the physical object.

After definite multiple scanning with respect to different angles the acquired data points are reformed into ASCII (.asc) file format type or STL format based on the software usage convenience. This point cloud data is imported into CreoRex 3.0 software, here we modify the point cloud data into a free form surface by following few steps they are Noise reduction, Sampling, wrapping defect, Smoothing a Mesh surface , Diagnostics, Filling holes and Simplifying the model. **[7]**Then the RE BASED model is obtained which is compared with the original CAD model to evaluate the deviations.

The next step after these operations is the model should be established in X,Y & Z planes on both the test and reference objects so that test object should be reoriented in such a way that three planes should match the reference planes**.[8]**

Now for understanding the difference between the selected area on the object is represented by colour coded mappings. From this we get the tolerance, standard deviation, average deviation values individually for different test models and the final deviations are compared between the both EINSCAN and 3D CAPTURE scanners and we conclude by evaluating the better scan performance on the freeform surface of a physical object.**[9]**

5. RESULTS AND DISCUSSION

We have to consider the deviations in shape, dimensions and in orientation as evaluating characteristics. By keeping tolerance as 0.5mm we should compare RE model with CAD model for individual scanners.

5.1. Comparison of Deviation distribution (Table 3)

Table 3

Comparison of deviation distribution between the scanners

EIN SCANNER				3D CAPTURE SCANNER			
>=Min	<Max	#points	%	>=Min	<Max	3points	%
-0.5000	-0.4100	31437	4.7494	-0.5000	-0.4248	303	0.1516
-0.4100	-0.3200	8806	1.3304	-0.4248	-0.3496	956	0.4784
-0.3200	-0.2300	7721	1.1665	-0.3496	-0.2744	2444	1.2230
-0.2300	-0.1400	10677	1.6730	-0.2744	-0.1993	5440	2.7222
-0.1400	-0.500	17128	2.5876	-0.1993	-0.1241	10072	5.0400
-0.0500	0.0500	29562	4.4661	-0.1241	-0.0489	17202	8.6076
0.0500	0.1400	63388	9.5764	-0.0489	0.0489	54347	27.1953
0.1400	0.2300	85560	12.9260	0.0489	0.1241	52400	26.2210
0.2300	0.3200	91335	13.7985	0.1241	0.1993	38956	19.4936
0.3200	0.4100	90208	13.6282	0.1993	0.2744	13834	6.9225
0.4100	0.5000	38096	5.7554	0.2744	0.3496	2168	1.0849
Out of Upper Critical		30256	4.5709	Out of Upper Critical		0	0.0000
Out of Lower critical		157748	23.8318	Out of Lower critical		0	0.0000

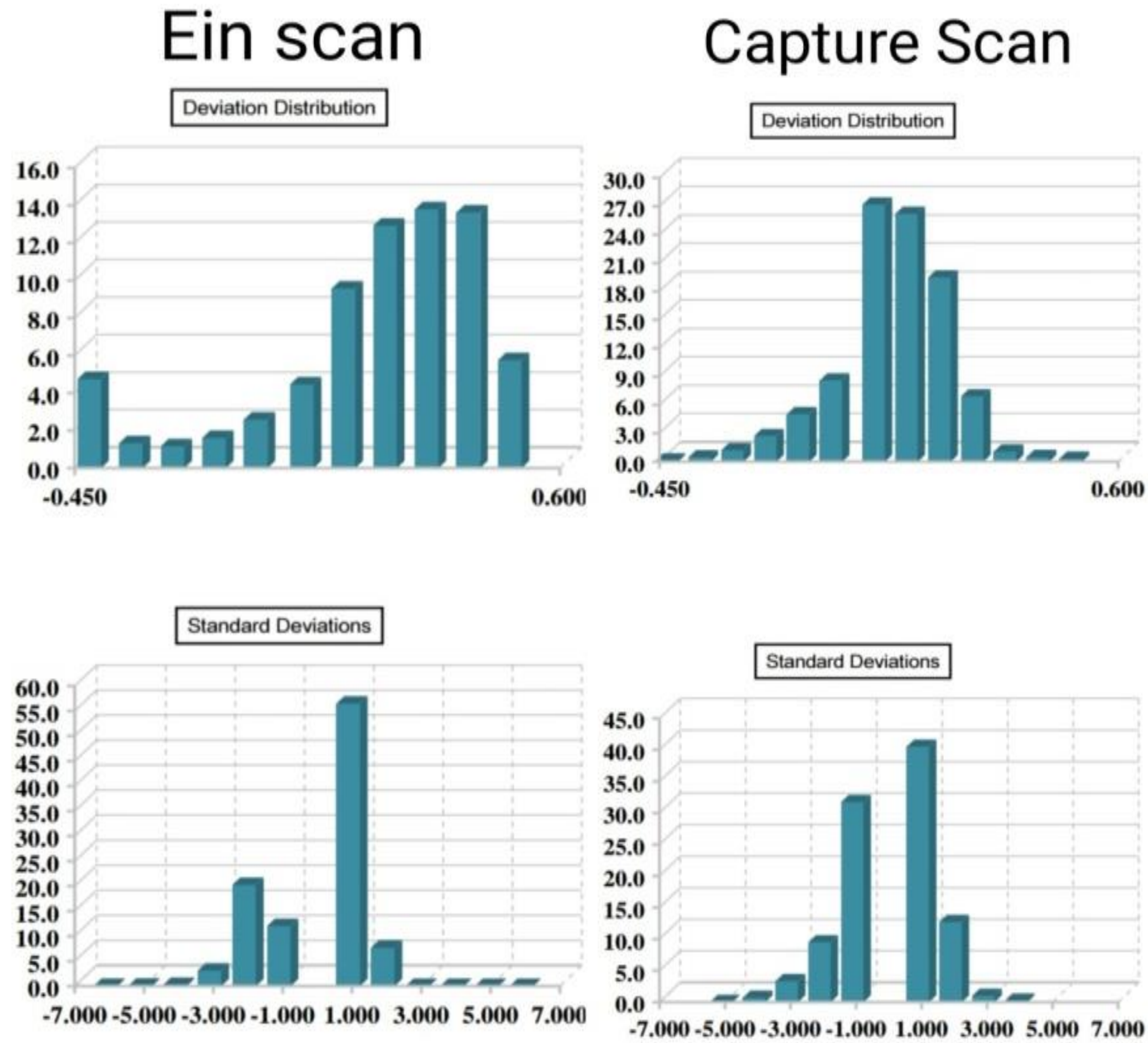
5.2. Comparison of Standard deviations: (Table 4)

Table 4
Comparison of standard deviations between scanners

EIN SCANNER			3D CAPTURE SCANNER		
Distribution (+/-)	#points	%	Distribution (+/-)	#points	%
-6*Std. Dev	262	0.0396	-6*Std. Dev	0	0.0000
-5*Std. Dev	639	0.0965	-5*Std. Dev	111	0.0555
-4*Std. Dev	1678	0.2535	-4*Std. Dev	1473	0.7371
-3*Std. Dev	20653	3.1202	-3*Std. Dev	6719	3.3622
-2*Std. Dev	134014	20.2462	-2*Std. Dev	19009	9.5121
-1*Std. Dev	79527	12.0146	-1*Std. Dev	63452	31.7514
1*Std. Dev	373941	56.4932	1*Std. Dev	80992	40.5284
2*Std. Dev	50954	7.6979	2*Std. Dev	25460	12.7402
3*Std. Dev	155	0.0234	3*Std. Dev	2068	1.0348
4*Std. Dev	86	0.0130	4*Std. Dev	556	0.2782
5*Std. Dev	9	0.0014	5*Std. Dev	0	0.0000
6*Std. Dev	4	0.0006	6*Std. Dev	0	0.0000

5.3. Analysis by graphical representation

Analysis by graphical representation between Ein scanner and Capture scanner when individually compared with original CAD model with RE based model.



By comparing the original CAD with RE based model deviation graphs are obtained, from the above deviations graphs we can conclude that capture 3D scanner has less deviations than that of ein scanner.

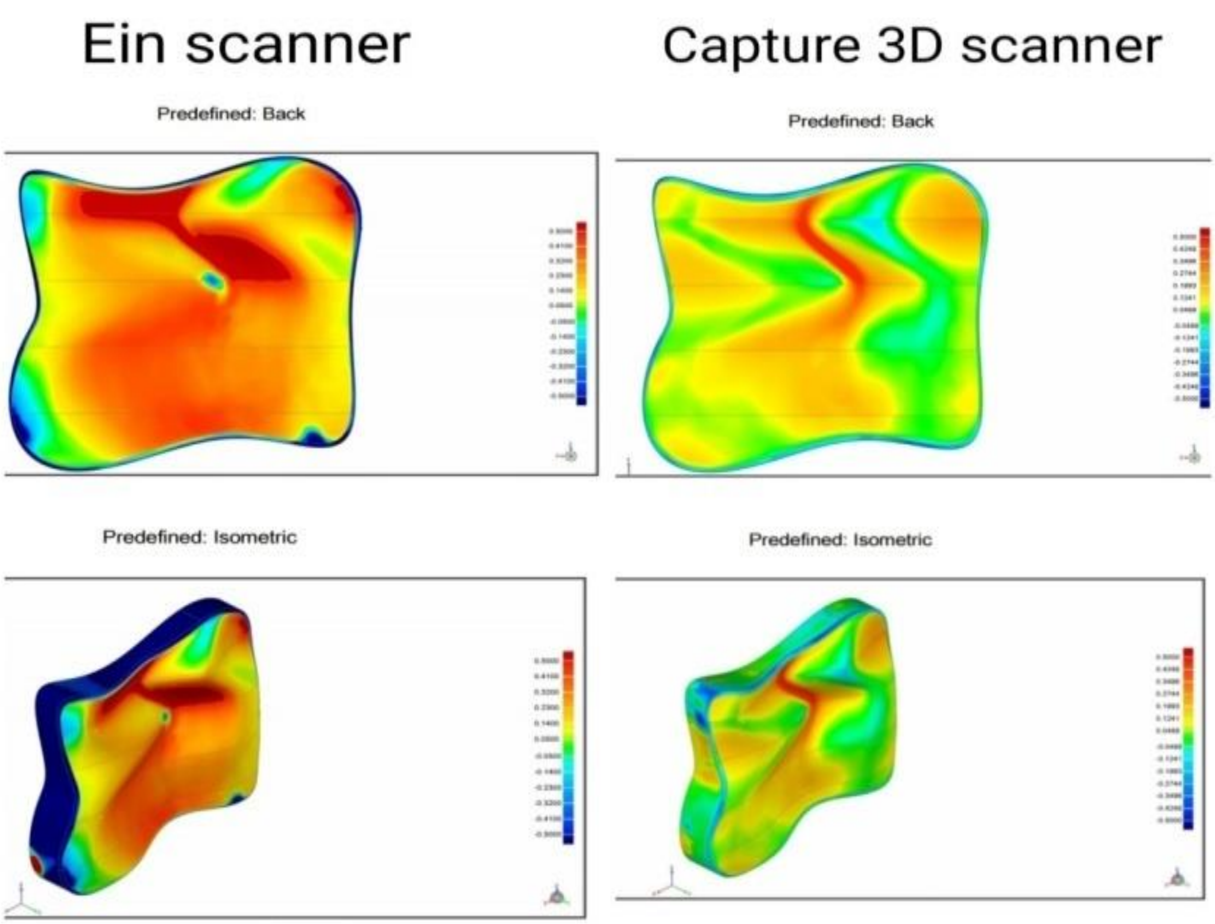
5.4. Location set (Table 5)

						EINSCAN		3D CAPTURE	
Name	**Upper Tol**	**Lower Tol**	**Ref. X**	**Ref. Y**	**Ref. Z**	**Dev.**	**Status**	**Dev.**	**Status**
L1	0.1372	-0.1372	-137.18	11.94	109.74	-06604	FAIL	-0.0674	PASS
L2	0.1372	-0.1372	-109.74	16.85	137.18	0.1434	FAIL	0.0242	PASS
L3	0.1372	-0.1372	-109.74	19.68	82.30	-0.0343	PASS	0.0843	PASS
L4	0.1372	-0.1372	-109.74	19.55	27.43	0.4053	FAIL	0.0111	PASS

L5	0.1372	-0.1372	-109.74	23.99	54.87	0.2614	FAIL	-0.0137	PASS
L6	0.1372	-0.1372	-109.74	21.33	109.74	0.2347	FAIL	0.1500	FAIL
L7	0.1372	-0.1372	-82.30	12.83	54.87	0.2087	FAIL	0.1492	FAIL
L8	0.1372	-0.1372	-82.30	11.02	82.30	0.3293	FAIL	0.1970	FAIL
L9	0.1372	-0.1372	-82.30	11.94	27.43	0.4377	FAIL	0.1480	FAIL
L10	0.1372	-0.1372	-82.30	16.57	109.74	0.4261	FAIL	0.0321	PASS
L11	0.1372	-0.1372	-54.87	18.28	27.43	0.3821	FAIL	0.0861	PASS
L12	0.1372	-0.1372	-54.87	12.59	109.74	0.3598	FAIL	0.2018	FAIL
L13	0.1372	-0.1372	-54.87	21.65	82.30	0.4122	FAIL	0.0745	PASS
L14	0.1372	-0.1372	-54.87	15.82	54.87	0.2826	FAIL	0.1756	FAIL
L15	0.1372	-0.1372	-27.43	24.49	54.87	0.2332	FAIL	0.0957	PASS
L16	0.1372	-0.1372	-27.43	20.86	82.30	0.1151	PASS	0.1444	FAIL
L17	0.1372	-0.1372	-27.43	24.67	27.43	0.2375	FAIL	0.0521	PASS
L18	0.1372	-0.1372	-27.43	21.22	109.74	0.1316	PASS	0.0413	PASS

Here in this deviation status is compared at 18 predefined points by PASS or FAIL. This table shows that the Ein scanner has maximum failures at L1,L2,L4,L5,L6,L7,L8,L9,L10,L11,L12,L13,L14,L15,L17, and passes at L3,L16,L18 points. Whereas the Capture scanner has minimum failures compared to the Ein scanner and the failure points of capture scanner at L6,L7,L8,L9,L14,L16.

5.5. Pictorial compared results



Above Isometric view and Back view pictures are the 3D compared results acquired by comparing Reverse Engineering model followed by **EIN SCAN** Scanner and **CAPTURE 3D SCANNER** with the original CAD model respectively. In the picture Red colour indicates maximum deviation, green indicates tolerable/optimal deviation, blue indicates no deviation.

6. CONCLUSION

For the evaluation process we use complex freeform surface i.e, having deep curved profiles. The comparative results of case study tell that scanner with **Capture scanner** (fast blue light phenomenon) has **Greater accuracy** compared to the **Ein scanner.**

The results which are acquired from individual scans were summarized in the table 3 & 4 and the comparison of RE-model and CAD model is shown. The variation ranges are small in Capture scanner compared to the Einscan, as Capture has minimum point to point distance and has high resolution to the complex freeform surface. By increasing the number of scans we can obtain more accurate and precise evaluation of deviation distribution. Further by using V5 perceptron laser scanner the deviations obtained are compared with this Capture scanner and Ein scanner for better evaluation.

DISCLOSURE STATEMENT

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